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RESPONSE OF ECO-FRIENDLY SEED COATING TECHNIQUES ON PHYSIOLOGICAL ATTRIBUTES OF FINGER MILLET VARIETIES

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Abstract– An experiment was carried out to investigate the effects of different botanical extracts on germination, vigor and seedling growth performance of finger millet varieties under laboratory condition at Department of Seed Science and Technology Laboratory, SGRR University, Dehradun. The experiment was conducted by using eight different botanical extracts on three finger millet varieties seeds used as treatments along with control treatment (untreated seeds). Total twenty seven treatments combinations were replicated in four replications in factorial randomize block design. The treated and untreated seeds were used for germination and vigour test under optimal germination conditions for ten days. The experimental findings are indicated that the botanical treatments significantly influenced the seed germination and seedling growth of finger millet varieties. Among eight eco-friendly seed coating agents, the treatment of Rhododendron extract (T_1) proved to be the most efficacious, exhibiting the highest germination percentage (92.88%), the quickest germination rate (4.61), and the greatest seedling vigor indices (VI-I; 1117.45 & VI-II; 8.36). The interaction effects between varieties and coating materials considerably enhanced the performance with Rhododendron extract coating (T_2), especially when applied with variety VL379. Thus it can be concluded that the variety VL379 perform best with Rhododendron seed coating among all other treatments for higher seeds quality of finger millet.

INTRODUCTION

Finger millet (*Eleusine coracana L.*) is minor millet which widely farmed in India. It is one of the oldest crop in India, which referred to as "nrtta-kondaka" in ancient Indian Sanskrit literature, meaning "Dancing grain," and is also known as "rajika" or "markataka" (Achaya, 2009). The earliest documentation of finger millet originates from Hallur in Karnataka, India, about 2300 BC (Singh, 2008). Finger millet is nutritionally dense, drought-resistant crops predominantly cultivated in the arid and semi-arid areas of India. It is a substantial source of calcium (300-350 mg/100 g), phosphorus (283 mg/100 g), and iron (3.9 g/100 g), as well as vitamins B1, B2, folic acid and niacin (Singh, 2008). It facilitates natural weight reduction, fortifies bones, mitigates diabetes, combats aging, regulates blood pressure, offers illness protection, and enhances hemoglobin levels in youngsters (Chethan and Malleshi, 2007). In the fiscal year 2024, Karnataka emerged as the foremost producer of ragi in India, yielding over 865 thousand metric tons. Subsequently, the states of Tamil Nadu and Uttarakhand were included (Agricultural Statistics, 2024).

Varietal selection is crucial in agricultural research, since it directly affects the reliability, repeatability and application of experimental results. Diverse seeds types exhibit distinct genetic characteristics that influence their adaptability to environmental circumstances, higher germination, seedling growth, tolerance to pests and diseases, nutrient absorption efficiency and total production potential. Selecting the suitable variety is guarantee that the study aims correspond with the plant's biological traits, hence reducing confounding variables and improving the validity of the findings.

Furthermore, varietal selection is essential for evaluating treatments or practices among genotypes, as it facilitates the identification of variety-specific responses and genotype-by-environment interactions. Essentially, the meticulous selection of seed types constitutes the cornerstone of substantial agricultural research (Acquaah, 2012).

Management of seed quality is a crucial determinant affecting the productivity and sustainability of finger millet *(Eleusine coracana*). Quality seeds provide enhanced germination rates, consistent crop establishment and eventually superior yield, and grain quality. Efficient seed management includes the selection of genetically superior, disease-free and physiologically ripe seeds, as well as appropriate seed treatment and storage methods to preserve viability (Kumar *et al*., 2020). The research focuses on enhancing farmer understanding about seed management, and utilizing biotechnological methods for assessing varietal purity and seed health. Moreover, seed coating with botanicals have demonstrated effective outcomes in improving seed vigor and drought resistance in finger millet, essential for adjusting to unpredictable climatic circumstances (Nagaraja *et al*., 2019).

Seed coating is regarded as an effective technique for advancing sustainable agriculture by enhancing the physical and physiological characteristics of seeds to allow planting and augment growth indices. Eco-friendly management techniques, such as the utilization of plant extracts, are currently employed to control plant diseases, proving to be more efficient and cost-effective than chemical alternatives (Yadav *et al*., 2023). The various botanicals are having bioactive capabilities, which encompass antifungal, antibacterial, and growth-promoting chemicals. The aim of research is to assess the suitable eco-friendly plant extract (botanicals) for the management of seed quality that does not impact human health. Consequently, considering the aforementioned considerations, the current study was conducted to know the effects of eco-friendly seed coating techniques on germination and vigour of three finger millet varieties.

MATERIALS AND METHODS

Experimental area and treatments

The experiment was conducted in Seed Science and Technology laboratory at SGRR University Dehradun. The treatments were consist three different varieties of finger millet *i.e*., VL379 (V_1), VL352 (V_2) and Local mid hill variety (V_3) with eight different seed coating material. The eight eco-friendly seed coating materials used as treatments were Rhododendron (*Rhododendron arboreum*) (T_1), Bayberry (*Myrica*) (T_2), Garlic (*Allium Sativum*) (T_3), Turmeric (*Curcumalonga*) (T_4), Moringa (*Moringa oleifera*) (T_5), Tulsi (*Ocimum sanctum*) (T_6), Amla (*Phyllanthus emblica)* (T_7) and Neem (*Azadirachta indica)* (T_8) along with the control *i.e.* without any treatment (T_0). The finger millet seeds were coated with slurry of different botanicals (leaves, stems & bark parts of botanicals). The experiment was replicated in four replication in factorial randomize block design.

Seed quality parameters

The seed quality testing was done by following the ISTA method of seed quality testing (ISTA, 2013). The seed quality parameters like germination per cent, speed of germination, seedling growth, seedling weight, dry matter production, vigour index- I and vigour index- II were recorded during experiment and data were subjected to statistical analysis. The vigour index-I and vigour index-II were calculated by using method given by Abdul Baki and Anderson, 1973.

Statistical analysis

Data were collected from each treatments and mean data were subjected to statistical analysis. The statistical analysis was done by using SPSS software.

RESULTS AND DISCUSSION

Germination per cent

The germination per cent shows significant variability across cultivars and coating treatments (Table 1). The variety VL379 (V_1) had the highest germination per cent (86.88 %), followed by variety VL 352 (V_2) *i.e.* 82.80 % and mid hill local variety of Uttarakhand (V_3) *i.e.* 78.44 %. The highest germination percentage across coating treatments was seen in rhododendron (T_1) which was 92.88 %, whilst garlic coated seed (T_3) displayed the lowest germination per cent (73.10 %). The germination per cent was shows markedly variation when variety interact with coating materials, the variety VL379 with rhododendron coating (V_1T_1) demonstrating the maximum germination (96.00%), while local hill variety with turmeric coating (V_3T_4) recorded the

lowest germination per cent (62.66%). The greater germination in variety VL379 coated with rhododendron (V_1T_1) is likely due to the beneficial impact of the covering material, which may have improved seed hydration and protection (Singh *et al*., 2019). Sharma and Verma (2020) obtained same results, noting enhanced germination in coated seeds relative to untreated seeds. The findings indicate that coating materials influence seed germination, possibly by modifying the seed microenvironment (Singh *et al*., 2020).

Speed of germination (seedling/day)

The germination rate shows significant variation with respect to different treatments. Variety VL379 (V_1) was achieved the highest value 3.41 seedling/day and lowest by local hill variety (V_3), *i.e*. 2.04 seedling/day. Rhododendron treatment (T_2) had the maximum speed of germination (4.61 seedling/day) while treatment with Turmeric (T_4) displayed the minimum, *i.e.* 1.88 seedling/day. Accelerated germination signifies increased metabolic activity and enhanced water absorption (Kumar *et al*., 2019). The germination rate was highest when variety VL379 coated with rhododendron (V_1T_1), *i.e.* 5.10 seedling/day, followed by variety VL352 treated with rhododendron (V_2T_1), *i.e.* 4.91 and VL379 treated with bayberry (V_1T_2) which was 4.60, suggesting that certain coating materials enhanced germination. The decreased values in local hill variety with garlic (V_3T_3) and Tulsi V_3T_6 (1.12 & 1.26 seedling/day, respectively) indicate potential inhibition attributable to limited oxygen exchange or water absorption (Khan *et al*., 2018).

Fresh weight (g)

Marked discrepancies in fresh weight of seedlings were observed among treatments. Variety VL379 (V_1) demonstrated the highest fresh weight of seedling (0.72 g) and lowest was with local hill variety (V_3) *i.e.* 0.45 g. Among the coatings, Rhododendron (T_1) exhibited the highest fresh weight of seedling 0.89 g, signifying enhanced seedling vigor due to the effects of the coating. This highest fresh weight of seedling indicating the improved water retention and nutrient absorption during seed germination and seedling growth (Sharma and Patel, 2021). The fresh weight of seedling exhibited a same pattern with interaction effect of variety and coating material. The variety VL379 treated with rhododendron (V_1T_1) demonstrating the highest fresh weight accumulation (1.08 g) and lowest was recorded (0.29 g) by local hill variety treated with garlic (V_3T_3). This corroborates the findings of Rao *et al.* (2020), which demonstrated that appropriate seed coating materials substantially enhanced fresh weight.

Dry weight (g)

Significant variation in seedling dry weight was

Table 1. Effect of varieties and botanicals coating on seeds quality of finger millet seeds

Treatments	Germination %	Speed of germination (seedling/day)	Dry weight (g)	Fresh weight (g)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Vigour Index-I	Vigour Index II
Varieties									
V_1	86.88	3.41	0.06	0.72	4.66	3.34	8.00	695.04	5.21
V_2	82.80	3.19	0.05	0.51	4.53	3.46	7.99	661.57	4.14
V_3	78.44	2.04	0.04	0.45	3.86	3.00	6.86	538.10	3.14
SEm±	0.24	0.030	0.002	0.025	0.035	0.024	0.022	2.17	0.073
Cd (05%)	0.68	0.086	0.005	0.072	0.100	0.069	0.062	6.19	0.208
Seed coating									
T_0	79.54	2.57	0.04	0.41	2.11	2.24	4.35	346.00	3.18
T_1	92.88	4.61	0.09	0.89	6.80	5.23	12.03	1117.35	8.36
T_2	88.22	4.01	0.07	0.73	6.31	4.89	11.20	988.06	6.18
T_3	73.1	1.88	0.02	0.41	2.06	2.04	4.10	299.71	1.46
T_4	76.66	2.36	0.04	0.44	3.75	2.60	6.35	486.79	3.07
T_5	88.00	4.02	0.06	0.66	5.74	4.20	9.94	874.72	5.28
T_6	81.54	2.04	0.04	0.47	4.35	2.60	6.95	566.70	3.26
T_7	81.32	2.16	0.05	0.47	4.60	2.82	7.42	603.39	4.07
T_8	83.1	2.27	0.04	0.55	3.43	2.86	6.29	522.70	3.32
SEm±	0.41	0.052	0.003	0.044	0.106	0.042	0.038	3.771	0.127
Cd (05%)	1.18	0.148	0.009	0.125	0.174	0.119	0.108	10.73	0.361

observed among treatments. Variety VL379 (V_1) exhibited the highest dry weight (0.06 g), followed by VL352 (V_2) 0.05 g and lowest (0.04 g) with local hill variety (V_3). Among the coating treatments, Rhododendron (T_2) demonstrated the maximum seedling dry weight 0.09 g, followed by bayberry (T_2) and Moringa (T_5) treatment, *i.e.* 0.07 g & 0.06 g respectively, indicating that the coating materials significantly influence dry matter accumulation. Coatings can improve moisture retention and nutrient availability, leading to increased biomass production (Verma *et al.,* 2018). The lowest dry weight was observed in garlic treatment (T_3), *i.e.* 0.040 g, perhaps due to insufficient seed metabolism or reduced nutrient absorption. The findings support previous research demonstrating that seed coatings made from organic or polymeric materials promote seedling growth and biomass increase (Desai *et al.,* 2020).

Significant variation in seedling dry weight was detected with interaction of variety and coating treatments. Variety VL352 treated with rhododendron (V_1T_1) gives the maximum dry biomass of seedling (0.097 g). The minimum dry weight (0.027 g) was recorded with local hill variety treated with garlic (V_3T_3). Poor dry matter accumulation in seedlings may likely attributable to inadequate seedling vigor (Patel *et al.,* 2021).

Root length (cm)

Root length is a vital determinant influencing seedling establishment and nutrient uptake. Variety VL379 (V_1) exhibited the longest root length (4.66 cm), followed by VL352 (V_2), *i.e.* 4.53 cm and smallest seedling length (3.86 cm) with local hill variety (V3). Coating treatments significantly influenced the root length, coating treatment rhododendron (T_1) gives the maximum root length (6.80 cm), followed by bayberry treatment (T_2), *i.e.* 6.31cm and 5.74 cm with moringa (T_5). The

Table 2. Interaction effects of Varieties and botanicals coating on seeds quality of finger millet seeds

Treatments	Germination %	Speed of Germination (seedling/day)	Dry Weight (g)	Fresh weight (g)	Root length (cm)	Shoot length (cm)	Seedling length (cm)	Vigour Index I	Vigour Index II
V_1T_0	83.32	2.70	0.060	0.51	2.19	2.26	4.45	370.77	5.00
V_1T_1	96.00	5.10	0.097	1.08	7.21	5.54	12.75	1224.00	9.31
V_1T_2	94.00	4.60	0.077	0.93	7.09	4.76	11.85	1113.90	7.24
V_1T_3	76.00	2.27	0.040	0.39	2.16	2.13	4.29	326.04	3.04
V_1T_4	86.00	2.93	0.063	0.70	3.42	2.38	5.80	498.80	5.42
V_1T_5	92.00	4.44	0.080	0.82	6.97	4.60	11.57	1064.44	7.36
V_1T_6	84.66	2.72	0.057	0.54	5.10	2.85	7.95	673.05	4.83
V_1T_7	84.00	2.89	0.067	0.68	4.33	2.66	6.99	587.16	5.63
V_1T_8	86.00	3.02	0.067	0.86	3.48	2.87	6.35	546.10	5.76
V_2T_0	77.32	3.04	0.043	0.38	2.19	2.51	4.70	363.40	3.32
V_2T_1	94.00	4.91	0.096	0.84	7.18	5.02	12.20	1197.56	9.02
V_2T_2	87.32	4.32	0.080	0.67	7.04	4.99	12.03	1050.46	6.99
V_2T_3	74.00	2.25	0.027	0.56	2.16	2.08	4.24	313.76	2.00
V_2T_4	81.32	2.83	0.050	0.31	4.34	3.57	7.91	643.24	4.07
V_2T_5	86.66	4.55	0.063	0.59	5.16	4.12	9.28	804.20	5.46
V_2T_6	82.00	2.15	0.043	0.47	4.20	2.50	6.70	549.40	3.53
V_2T_7	79.32	2.26	0.050	0.38	4.81	3.61	8.42	667.87	3.97
V_2T_8	83.32	2.42	0.043	0.41	3.18	2.94	6.12	509.92	3.58
V_3T_0	78.00	1.96	0.027	0.35	1.96	1.93	3.89	303.42	2.11
V_3T_1	88.66	3.81	0.073	0.74	5.47	5.14	10.61	940.68	6.47
V_3T_2	83.32	3.12	0.057	0.59	4.79	4.94	9.73	810.70	4.75
V_3T_3	69.32	1.12	0.020	0.29	1.86	1.91	3.77	261.34	1.39
V_3T_4	62.66	1.33	0.030	0.32	3.50	1.84	5.34	334.60	1.88
V_3T_5	85.32	3.08	0.060	0.58	5.10	3.87	8.97	765.32	5.12
V_3T_6	78.00	1.26	0.043	0.41	3.75	2.46	6.21	484.38	3.35
V_3T_7	80.66	1.35	0.047	0.36	4.68	2.18	6.86	553.33	3.79
V_3T_8	80.00	1.36	0.037	0.38	3.43	2.77	6.20	496.00	2.96
SEm±	0.722	0.090	0.005	0.076	0.106	0.042	0.066	6.531	0.220
Cd (05%)	2.054	0.257	0.013	0.011	0.301	0.119	0.186	18.588	0.625

minimum root length was recorded (2.06 cm) with garlic treatment (T_4). This increased root length with rhododendron coating (T_1), results from the beneficial effects of seed coating, which enhances water absorption, alleviates environmental stress, and promotes early root development (Verma *et al.,* 2018).

The maximum root length was recorded (7.21 cm) when variety VL379 treated with rhododendron (V_1T_1), while the minimum was recorded (1.86 cm) with local hill variety treated with garlic (V_3T_3). Augmented root elongation in VL379 with rhododendron (V_1T_1) indicates enhanced nutrition and water uptake, whereas the abbreviated roots in local hill variety treated with garlic (V_3T_3) may signify constrained development because to inappropriate coating material. These finding are also in agreement with findings of Kumar et al., 2017.

Shoot length (cm)

The higher shoot length is a crucial indicator of higher seedling vigor and plant establishment. Variety VL379 (V_1) exhibited the longest shoot length (3.34 cm), while local hill variety (V_3) recorded the shortest (3.00 cm) shoot length. Among the coating treatments, rhododendron (T_1) had the maximum shoot length (5.23 cm), which confirming that the seed coating favorably influence shoot development of finger millet. Previous studies demonstrate that the use of biopolymers and nutrients enhances shoot elongation (Verma *et al.,* 2018). The longest shoot length was recorded (5.54 cm) with variety VL379 treatment with rhododendron coating (V_1T_1), followed by variety VL352 with rhododendron treatment (V_2T_1) i.e. 5.02 cm. The smallest shoot length was noted (1.91 cm) in local hill variety treatment with garlic coating (V_3T_3). The results underscore the significance of suitable coating materials in facilitating shoot elongation (Meena *et al.,* 2018).

Seedling length (cm)

The length of seedling is an essential indicator of early growth performance of plant. The maximum length of seedling was recorded (8.00 cm) in VL379 (V_1) and minimum (6.86 cm) in local hill variety (V_3). Rhododendron treatment (T_1) demonstrated the longest seedling length (12.03 cm) among all other coating treatment. The interaction effect of variety and coating treatment show that the maximum seedling was recorded (12.75 cm) when variety VL 379 treated with rhododendron coating (V_1T_1), followed by treatment combination V_2T_2 (12.20 cm). It might be due to the improved nutrient absorption and reduced abiotic stress (Desai *et al.,* 2020). The minimum seedling length was recorded (3.77 cm) with interaction of local hill variety with garlic coating (V_3T_3).

Vigour Index - I

The variety VL379 (V_1) had the highest Vigour index-I (695.04) among the cultivars, signifying improved seedling establishment. The coating treatment shows the maximum vigor index-I was recorded (1117.35) with rhododendron treatment (T_1). These findings are also in agreement with the findings of Mandal *et al.,* 2017. The Vigour Index- I, indicative of seedling strength, was markedly elevated in VL379 and VL352 when treated with rhododendron, *i.e.* 1224.00 and 1197.56, respectively. The lowest value was recorded with local hill variety treated with garlic (V_3T_3) *i.e.* 261.34. The findings demonstrate that certain seed covering substances enhance seedling vigor (Gupta and Rao, 2019).

Vigour index- II

The vigour index-II varies significantly with different variety and coating treatments. The variety VL379 (V_1) shows the maximum Vigour index- II (5.21) among the cultivars, signifying improved seedling establishment. Rhododendron coated treatment (T_1) had the highest Vigour index- II (8.36) among the coating treatments, highlighting the importance of coatings in enhancing seed vigor. The interaction effect shows that the Vigour index- II, which integrates seedling biomass and germination rates, was highest (9.31) in variety VL379 treated with rhododendron (V_1T_1) and lowest (1.39) in local hill variety treated with garlic (V_3T_3). Elevated values indicate enhanced seedling establishment and survival potential (Das *et al.,* 2020).

CONCLUSION

The research indicated that seed coating with environmentally sustainable botanical substances markedly improved the quality characteristics of finger millet cultivars. Among three varieties, VL379 consistently demonstrated improved germination and vigour 86.88%, seedling vigor, and biomass accumulation relative to VL352 (V_2) and the local hill variety (V_3). The seed coating treatment utilizing

Rhododendron (T_1) exhibited the most significant enhancements, achieving a germination rate of 92.88%, a vigor index-I of 1106.52, and increased root and shoot lengths. The interaction effect of VL379 (V_1) coated with Rhododendron (V_1T_1) produced optimal performance across all metrics, including maximum germination 96.00% and seedling length 12.41cm. These findings validate that environmentally sustainable seed coverings may significantly enhance finger millet seed germination, seedling development, and vigor, providing a sustainable method for crop establishment.

Conflict of Interest – None

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